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STUDY OF THE PLANNED N.E. PACIFIC STREET HOV FACILITY

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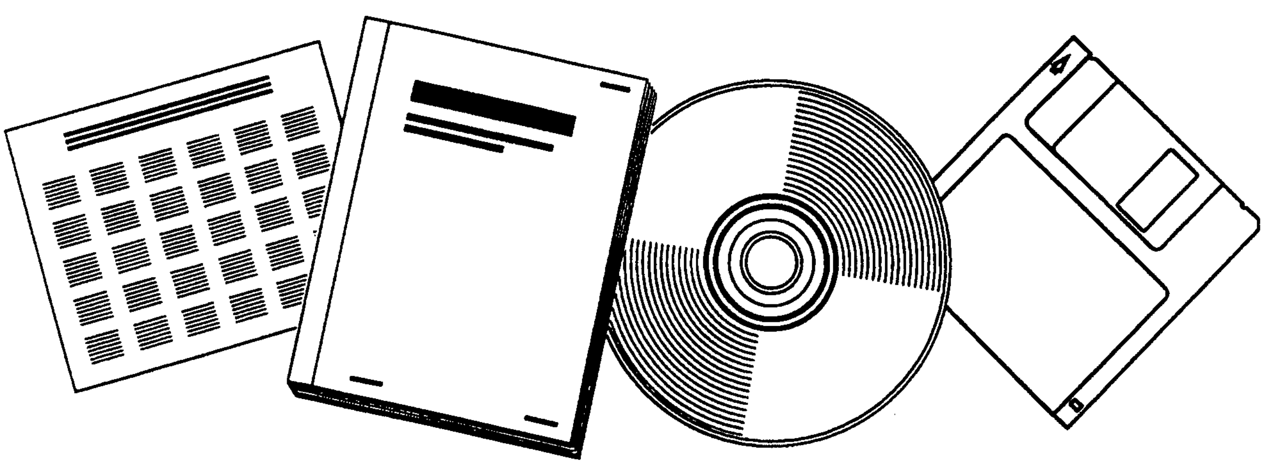

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PB98-110893

A STUDY OF THE PLANNED N.E. PACIFIC STREET HOV FACILITY

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16. Abstract
This report presents an analysis of HOV improvements for two signalized arterials in the Seattle metropolitan area. The first involves a planned 1,000 foot queue jumper lane on NE Pacific St. in the University District of Seattle. This planned improvement was studied prior to its implementation in Spring of 1990. As part of this study, an extensive before-data set was developed. The planned improvement is now in place, and an extensive after-study is now in progress as part of a follow-up project. The second study was more of a feasibility analysis of possible HOV improvements for a suburban arterial.. Specifically, NE 85th/Redmond Way, a 2.5 mile stretch of arterial from Interstate 405 in Kirkland to Willows Road in Redmond, was identified as one of the highest priority arterials to be considered for HOV improvements.

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SUMMARY

This report presents an analysis of HOV improvements for two signalized arterials in the Seattle metropolitan area. The first involves a planned 1,000 foot queue jumper lane on NE Pacific St. in the University District of Seattle. This planned improvement was studied prior to its implementation in Spring of 1990. As part of this study, an extensive before-data set was developed. The planned improvement is now in place, and an extensive after-study is now in progress as part of a follow-up project. The second study was more of a feasibility analysis of possible HOV improvements for a suburban arterial. Specifically, NE 85th/Redmond Way, a 2.5 mile stretch of arterial from Interstate 405 in Kirkland to Willows Road in Redmond, was identified as one of the highest priority arterials to be considered for HOV improvements.

Because of the limited arterial HOV experience in Seattle and nationwide, the study of these two very different type of HOV arterial improvements provided important information for future arterial plans. This project investigated HOV improvements for arterials in the Seattle area, simulated the operation of those improvements for the two case studies, developed a data set for evaluating the impacts of the improvements, and performed some preliminary evaluations.

The extensive before-data collection for the NE Pacific St. HOV study indicated that the commuter population had a good potential for mode shift. Also, the simulation runs for NE Pacific St. tended to reinforce the specific design decisions of the HOV facility plan. The suggested improvement passed the rule of thumb criterion of a difference in travel time between general traffic and the HOV lane of over one minute per HOV lane mile. These facts, coupled with the surrounding network of HOV facilities serving this arterial link, suggested that the planned 3+ queue jumper lane would in fact be considered a success. Because of the extensive before-data collection developed for NE Pacific St., this conclusion can and will be tested in an ongoing follow-up study sponsored by TransNow and Metro.

Similar findings were obtained for the suburban arterial NE 85th St. The traveller's survey showed that existing traffic already had a substantial number of 2+ carpoolers and suggested that a 2+ carpool lane would be cost-effective. The simulation results supported this conclusion for eastbound traffic and, with expected increased traffic volumes, indicated a similar conclusion for westbound traffic.

Thus the preliminary findings of these two case studies suggested favorable outcomes for the planned HOV improvements. Keeping in mind, that these analyses must be evaluated in the context of the surrounding network, a report on these two case studies is optimistic.

INTRODUCTION AND BACKGROUND

The Need for Arterial HOV Studies

Funding constraints and social and environmental impacts of new construction are forcing the Washington State Department of Transportation (WSDOT) to rely heavily on HOV facilities for improving personal mobility in the State's urban areas. To encourage high occupancy vehicle (HOV) usage, the WSDOT and various local agencies are providing incentives for people to use HOV modes by constructing and operating a series of facilities exclusively for HOVs.

At the time of this study, very few HOV improvements had been planned or implemented on arterials in the Seattle area. A bus-only lane operated on Bothell Way (SR-522) just North of the Seattle city limits; the City of Seattle operated a HOV lane northbound on Aurora Avenue (SR-99) approaching the city limits; and the City of Seattle had peak period bus-only lanes on some downtown streets. However, the City of Seattle and METRO transit were also planning a HOV facility on NE Pacific Street in the University District. Also, as part of the Eastside Transportation Program (ETP), the cities of Kirkland and Redmond, METRO transit, and WSDOT were investigating ways to improve personal mobility in the urban and suburban areas east of Lake Washington. HOV improvements on arterials were being discussed as part of this program. Specifically, NE 85th/Redmond Way, a 2.5 mile stretch of arterial from interstate 405 in Kirkland to Willows Road in Redmond, was identified as one of the highest priority arterials to be improved in this way.

Because of limited arterial HOV experience in Seattle and nationwide, further study was required to determine what types of HOV improvements were appropriate for arterials in the Seattle area and to evaluate the impacts of those improvements. This project investigated such improvements, simulated the operation of those improvements, developed a data set for evaluating the impacts of implementing the improvements, and performed some preliminary evaluations.

Research Objectives

The objectives for this project were to:

1) Investigate state-of-the-art techniques for providing high occupancy vehicle (HOV) incentives on arterial routes,

2) Generate HOV alternatives for use on arterials in Washington State urban areas,

3) Simulate the operation of selected HOV improvements in two arterial case study locations (NE Pacific St. in Seattle and NE 85th St. in Redmond and Kirkland),

4) Develop a complete before-data set for NE Pacific St. to be used in subsequent evaluations, and

5) Make preliminary evaluations of the selected arterial HOV improvements on the basis of the simulations of the two arterials noted above and field observations of NE Pacific St.

REVIEW OF PREVIOUS WORK

Existing Applications

A thorough review of over one-hundred major references preceded the project study. This state-of-the-art review (See Volume II of this report) summarized the work concerning HOV improvements on both freeways and arterials and determined that the problems associated with HOV improvements on arterials were, by far, the most challenging. It was further determined, that relatively few such applications existed and fewer studies of these applications were available. In fact, Seattle appeared to be one of the best sources for such information.

Seattle is one the few cities in the United States to have already implemented a restricted HOV lane on a non-CBD arterial, and there are three such applications here. Two of the three are on SR-522, a radial arterial connecting a freeway to the suburbs. It has a northbound HOV lane 0.92 miles long, and a southbound HOV lane 3.27 miles long. Both of these sections are restricted to buses and operate only during their respective peak flows. SR-99, or Aurora Avenue, extends from the CBD to well beyond the city limits. Its HOV lane goes through what could be called a suburban business district, basically a strip development along the arterial. This 1.5 mile HOV lane is northbound and open to 3+ carpools and transit and operates 24 hours a day. All three arterial HOV sections have been in place since the early 1980's.

Long range plans from groups like the Puget Sound Council of Governments (PSCOG) and the East side Transportation Program (ETP) show extension of the HOV network to all freeways and many of the main arterials in the Seattle area. Spurred by these plans, both Snohomish and King counties are actively pursuing their implementation. In most cases, the arterials in this metropolitan area are overburdened 2- or 4- lane facilities that transport cars from bedroom communities to the freeways. When major improvements are necessary, the designers are requested to make a full investigation of the possibilities of adding HOV lanes. However, since there is so little history on this kind of application, each agency is proceeding ahead in the dark, with many questions as to how the priority lane should look and operate, where it should begin and end, how it will interact with the adjoining lanes, and how the purchase of the necessary right-of-way will be funded. Interestingly, funding is one of the main factors in favor of large scale arterial HOV projects. The State of Washington has set aside a portion of the gas tax revenues to be used for city and county projects on a discretionary basis. This fund gives precedence to projects that include transit improvements and involve more than one jurisdiction. Obviously, HOV lane improvement on an arterial that goes through the county and one or more small cities ranks high on the discretionary list.

Nationwide, few suburban arterial HOV lanes are mentioned in the available literature. Studies of HOV applications in the US by the Institute of Transportation Engineers (ITE) in 1985 (1) and the Texas Transportation Institute (TTI) in 1990 (2) address only those on freeways or separate rights-of-ways. The only substantial report found that investigated arterial HOV treatments to any significant degree was published by Batz on 1986 (3). However, out of 95 arterial applications that were listed by Batz, the vast majority were for some type of CBD bus lane. Only 8 were on facilities that could be considered suburban. And of those eight, three were for buses only, one was a queue jumper, and two were on the two routes in Seattle. Even the Nihan/Davis report, which was the state-of-the-art review for this project, was unable to identify anything definite in the way of standard arterial HOV treatment. This dearth of experience and information contrasted with the interest shown in arterials at the Transportation Research Board's 1991 national HOV conference held in Seattle (4). Many informal comments expressed a real desire to know more about the feasibility and possibilities for arterial HOV treatments.

Not surprisingly, one of the most expensive studies done on the possibility of adding a full-use HOV lane (carpools and transit) to a suburban arterial was done in Seattle. The draft report of the Highway 99 High Occupancy Vehicle study by the TRANSPO Group, Inc. (5) is a proposal for a 15 mile inter-agency project involving four cities (Seattle, Edmonds, Lynnwood and Everett), two counties (King and Snohomish), two transit agencies (Seattle METRO and Community Transit), and the Washington State Department of Transportation. This study is a classic example of multi-criteria evaluation where three different alternatives are rated on nine quantifiable criteria. In actuality, only one criterion, travel time savings, seemed to carry much weight. Yet, an assumption of constant demand before and after the HOV improvement was made. Such an assumption produces unrealistically good travel times for the general purpose traffic, thereby affecting the evaluation based on relative travel times. At the time that this report was reviewed it was still in its draft form, and it has many hurdles to clear before it finds acceptance. Chief among these hurdles is the fact that its results have to please no less than nine separate agencies.

Upon completion of the literature review for the current study, we concluded that previous work on arterial HOV improvements would not provide much insight into the parameters for this study. Not only were there few studies on this subject, but those that were reported in the literature did not have sufficient before-data to provide a basis for analysis of the impacts of such improvements. In fact, the dearth of before-data was singled out by Batz as one of the most critical factors in the inability to evaluate arterial HOV improvements to date. Because of this, the research team for the current study decided to assemble a complete before-data set for use as a basis in an anticipated follow-up study on the NE Pacific St. arterial section.

Problems to Overcome

Safety is a major problem in the application of HOV lanes on arterial streets. Since these lanes must serve local bus routes, they must be on the right-hand side even though they are intended for high-speed traffic. Thus, we have the situation of carpools and buses traveling in high-speed conditions sandwiched between the slow lane of the general purpose traffic and the pedestrian sidewalk. Additionally, entering and exiting traffic from the adjacent properties must cross this higher speed lane to complete their maneuverers.

Most of the fears about safety for arterial HOV improvements derive from engineering judgement, experience, and common sense. There is little documentation of these safety hazards. Of the 95 arterials listed by Batz, nine were suspended because of poor enforcement or low utilization. Only two even mentioned safety as a problem, and one of those, an attempt to use a center left turn lane during peak hours, was actually closed due to accidents. The only report dealing strictly with arterial HOV safety that we have reviewed is by Larry Senn of WSDOT (6). This report addresses the safety issue for the Seattle area arterial HOV lanes. Of the two lanes on SR-522, which are peak-hour bus-only, he found no increases in accidents. However, on the 24-hour, full use HOV lane on SR-99, he found that the accident rate was significantly greater than that on a comparable adjacent section with no HOV lane. The accidents were "almost all related to opposing left turns across the HOV lane and lane changes onto the HOV lane." Senn's recommendations are to restrict access and to increase the visibility of the HOV lane by more painted diamonds and more visible dividing striping and buttons. The significance of community access to the arterial can be found in the comparison of accidents on the two Seattle arterials. Most of the HOV length on SR-522 has a median divider curb and few driveways which greatly reduces turning traffic across the HOV lane. However, on SR-99, there is a two-way left turn lane for the entire lane section and practically unrestricted access from the abutting properties. There is no curb and gutter, and only some raised curb marking driveways. Several lots have car access along the entire length of their frontage. This amount of access not only creates an accident hazard, but also slows down the priority vehicles by making them negotiate all of the crossing traffic.

Another problem for arterial HOV lanes is the slowing and blocking effect of buses using the lanes. It is a problem because bus priority is one of the main reasons for the HOV lane's existence and one of the biggest deterrents for carpools using it. There is little research on how carpoolers actually surmount the bus problem by either passing the bus and reentering the restricted lane or continuing in the general purpose lane. A very limited study by Rubstello (7) found that only 23% of carpools that entered the SR-99 carpool lane at the beginning were still in it a mile and half later. Whether this was due to bus traffic, turnouts at the corridor, or no time advantage, was not clear. One way of getting buses out of the way is provision of widened pullouts at each bus stop. However, there are difficulties with this solution in terms of cost, right-of-way, and bus reentry problems. Other problems that are unique challenges for arterial improvements have yet to be adequately covered in the literature. These include conflicts and congestion caused by turning movements, conflicts with bicyclists and pedestrians, and jurisdictional problems inherent with arterials that usually run through more than one jurisdiction.

PROCEDURES

Before-Data Collection for the Planned NE Pacific St. HOV Facility

Figure 1 shows the location of the study site for the NE Pacific St. study and Figure 2 gives a closer view of the study boundary and planned improvement. Much of the before-data for this site was collected from existing sources. These data included geometric measurements, signalization data, AWDT volume counts, transit information, accident summaries, and vehicle occupancy counts. Other data were collected during the course of the project from individual field observations. These included additional geometric measurements, signalization information, and other transit information. The key before-study measurements, however, were made with a five person team in the Spring of 1990.

The before measurements were accomplished by a team of five persons gathering data for either Montlake or NE Pacific during a series of collection periods. Data were collected simultaneously using synchronized lap top computers. In all cases the time of the observation was recorded automatically by the lap tops, allowing the observations to be related. Person 1 recorded licenses at the upstream end of the system. Person 2 recorded sex of driver and vehicle occupancy for the same vehicles recorded by person 1. Person 3 recorded license plates at the downstream end. Person 4 recorded the length of the queue at the Montlake intersection for either NE Pacific street or Montlake at the start of each green phase. Person 5 recorded the passing of each vehicle at the midway point between the upstream and downstream observations posts. This raw data provided the information necessary to create the various independent variables used in the analysis.

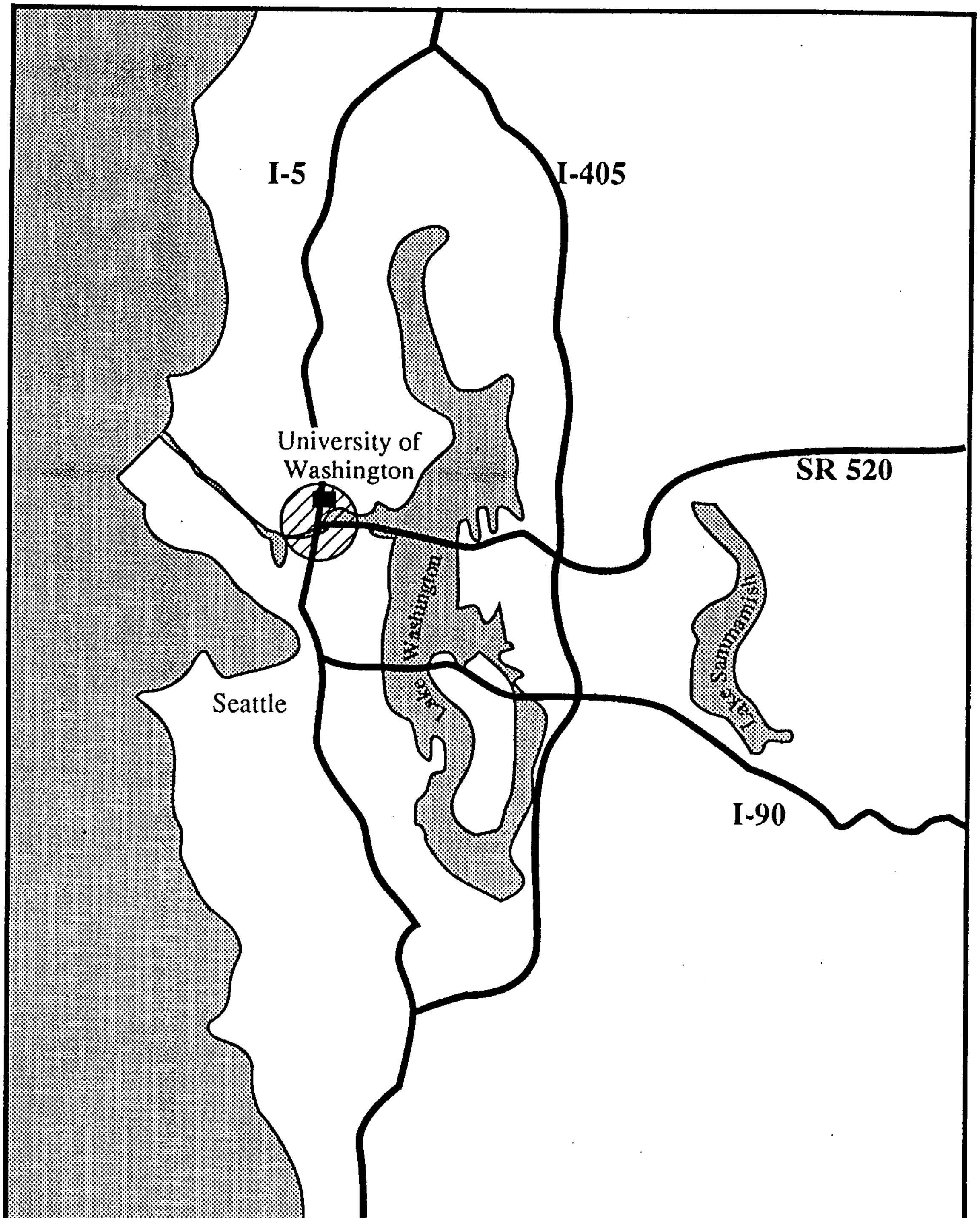

Figure 1. Location of NE Pacific Street Study Site

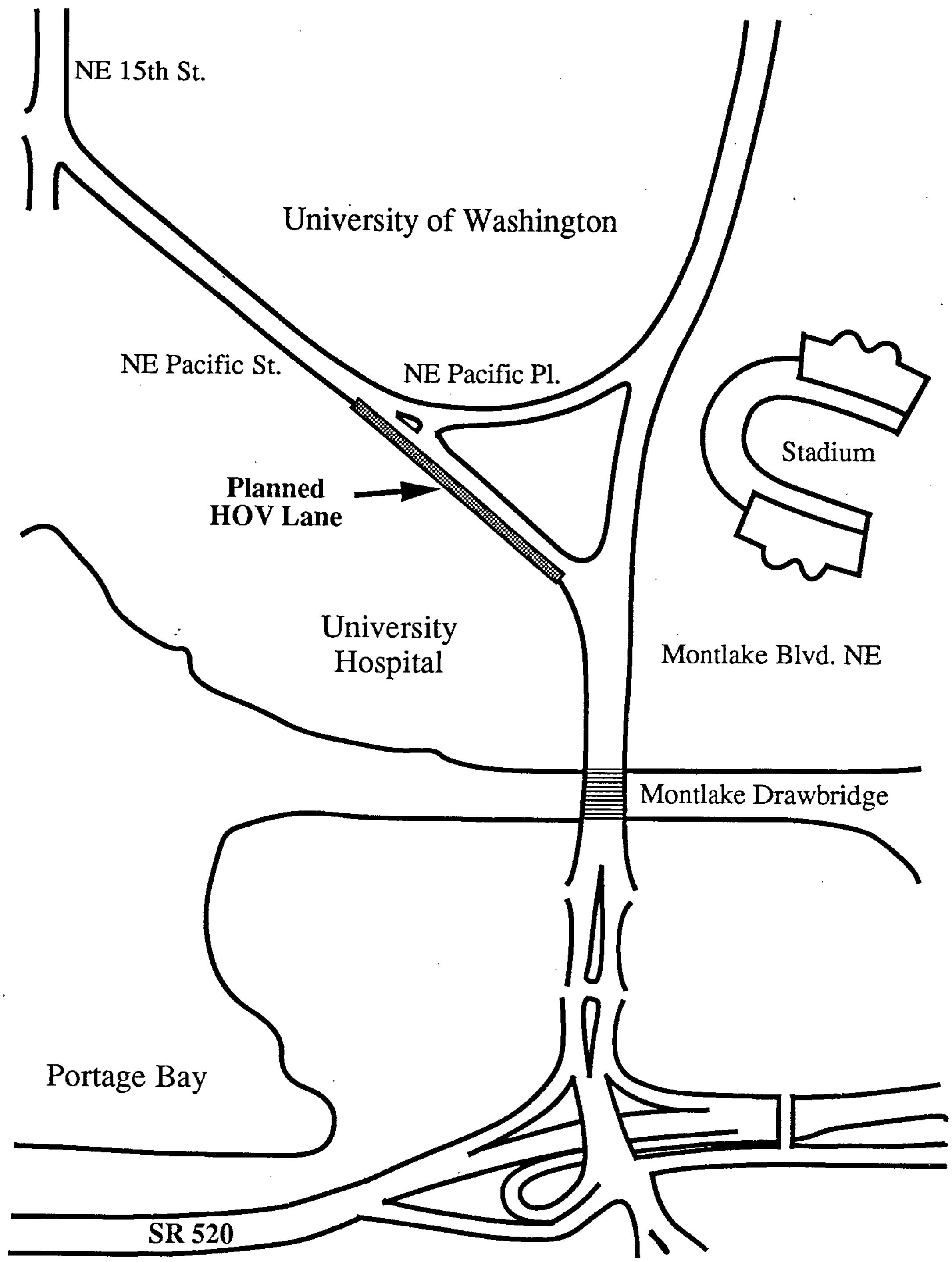

Figure 2. Location of the Planned NE Pacific HOV Lane.

Measurements were taken on five afternoons between March 30 and May 2. Taking into account the fact that the peak period is earlier in the U-district, beginning around 3 pm, our observations were made from 2:40 pm until 3:30 pm and from 3:45 pm until 4:45 pm with a 15-minute break. Observations were not made in the rain, forcing several postponements. Otherwise the weather was generally typical for Seattle, cool with occasional sun breaks. The last task of the five-person team was passing out mail-back postcards for the traveler's survey on the afternoon of May 23.

During the afternoon peak period from 2:30 until 5:30 pm, May 23, 1990, a mail-back postcard survey was conducted on Montlake Boulevard NE and NE Pacific Street at the Montlake intersection. Figure 3 shows a questionnaire that was included on each postcard. Postcards were handed to motorists waiting in queues at the Montlake intersection. These postcards had the travel survey questionnaire on one side and the return address and prepaid postage bar code on the other. Eight hundred fifty cards were passed out on both Montlake Blvd. NE and NE Pacific St.

The survey had several purposes. Questions one to seven were expected to provide information about trip origins and destinations, travel times, vehicle occupancies, trip purpose, age, sex and income. Questions eight to nine were expected to provide a broad measure of persons' attitudes towards carpooling and transit. In terms of the expected followup before-and-after study the information was expected to provided a base line against which changing origin-destination patterns, changing travel time patterns, and changing attitudes could be measured. Finally the surveys were expected to provide information for an estimated logit model for mode split analysis.

To get the same type of information from transit riders, an intercept was conducted at the bus stop in front of the University hospital during the afternoon peak period of May 24, 1990. Fifty persons waiting for buses were interviewed and asked the same survey questions.

TRAFFIC SURVEY

1. **Origin of Trip** (neighborhood or city where this trip started).

   Neighborhood or City ____________________ **ZIP CODE** ____________________

2. **Destination of Trip** (neighborhood or city where this trip will end).

   Neighborhood or City ____________________ **ZIP CODE** ____________________

3. Please indicate the **number of people in your vehicle** on this trip.

   (Please include driver) ______________ (Bus Riders please skip this question)

4. Exact **time of your departure** from origin ______________PM

5. Exact **time of your arrival** at destination ______________PM

6. Please indicate the **purpose of your trip** (check one)

   [ ] WORK [ ] SHOPPING [ ] SCHOOL

   [ ] SOCIAL-RECREATION [ ] OTHER ________________________

7. Your **Age** _________ **Sex** __________Approximate **Household Income $** ______________

8. (Check one) For me, driving alone is ...

   [ ] **always** better than a carpool

   [ ] **usually** better than a carpool

   [ ] **sometimes** better than a carpool

   [ ] **seldom** better than a carpool

   [ ] **never** better than a carpool

9. (Check one) For me, driving alone is ...

   [ ] **always** better than a bus

   [ ] **usually** better than a bus

   [ ] **sometimes** better than a bus

   [ ] **seldom** better than a bus

   [ ] **never** better than a bus

10. **Thank you for helping.**

COMMENTS ____

____

____

Figure 3. Survey Questionnaire for NE Pacific Street Travel Survey

Northeast 85th HOV Travel Survey

As previously mentioned, the East side Transportation Program (ETP), a cooperative planning effort by all government agencies involved with transportation issues east of Lake Washington, recommended an integrated system of arterial HOV improvements linking east side activity centers to the regional HOV system. Northeast 85th/Redmond Way connecting Interstate 405 in Kirkland to Willows Road in Redmond was identified as one of the highest priority arterials to be improved in this way.

For this 2.5 mile arterial, a motorist survey was handed out to collect data describing commuter trip behavior. (see Figure 4.) Questions about trip origin, destination, and purpose were asked to determine what residential and commercial zones were being served by Northeast 85th/Redmond Way, and for what purpose. The questionnaire also requested information on the duration of the trip and the occupancy of the vehicle. These data were used as input for a mathematical model to predict the volumes on the facility one year after the implementation of an HOV lane. The final questions on the survey concerned the motorists' own predictions about how likely they were to carpool and what they thought were some of the problems preventing them from carpooling.

Figure 5 shows the location of the Northeast 85th corridor in the Seattle Metropolitan area and Figure 6 shows a close-up of the study boundary. It runs east/west between Kirkland and Redmond on the east side of Lake Washington. Its interchange with Interstate 405, the western terminus of the study area, is approximately 11 miles from downtown Seattle by freeway. From the I-405 interchange in Kirkland, NE 85th runs east and south through Redmond. The eastern boundary of the study section is Willows Road, giving a length of 2.4 miles. This general location makes NE 85th an intra-suburban arterial that serves trips going to other suburban destinations more than trips to downtown Seattle. The suburban population that this arterial serves is primarily auto-oriented.

TRAVEL PATTERN SURVEY

Station No. [ ][ ]　　　　Date [ ][ ][ ][ ][ ][ ]
Time [ ][ ]　　　　AM [ ]　　　　PM [ ]

Do not write above this line.

---

1. Origin of Trip (exact address, or closest intersection or place where this trip started.)　　1. [ ][ ][ ][ ]

____

____

2. Destination of Trip (exact address, or closet intersection or place where this trip will end.)　　2. [ ][ ][ ][ ]

____

____

3. Please indicate the number of people in your vehicle on this trip. (Please include driver) __________.　　3. [ ][ ]

4. Exact time of departure from origin _______________.　　4. [ ][ ][ ][ ]

5. Exact time of arrival at destination _______________.　　5. [ ][ ][ ][ ]

6. Frequency of trips _______ per day or _______ per week using this route.　　6a. [ ][ ][ ]
6b. [ ][ ][ ]

7. Please indicate the purpose of trip (check one)　　7. [ ][ ][ ]

[ ] Work　　[ ] Shopping　　[ ] School
[ ] Social-recreation　　[ ] Other

8. If High Occupancy Vehicle (HOV) lanes were installed in both directions on Redmond Way (N.E. 85th), from I-405 to 148th N.E., how likely would you be to join a carpool for your commute to work?　　8. [ ][ ]

[ ] Definitely would carpool　　[ ] Somewhat likely to carpool
[ ] Very likely to carpool　　[ ] Definitely would not carpool

9. Which of the following factors would make carpooling to work difficult for you?　　9. [ ][ ]
[ ] Home location (few possible ridesharers nearby)
[ ] Work location (few possible ridesharers nearby)
[ ] Hours of the day you work (odd times or frequent O.T.)
[ ] Number of days of the week you go to work (less than 4 or irregular)

Comments:__________________________________

____　　[ ]

____

____

Figure 4. Survey Questionnaire for NE 85th Street Travel Survey.

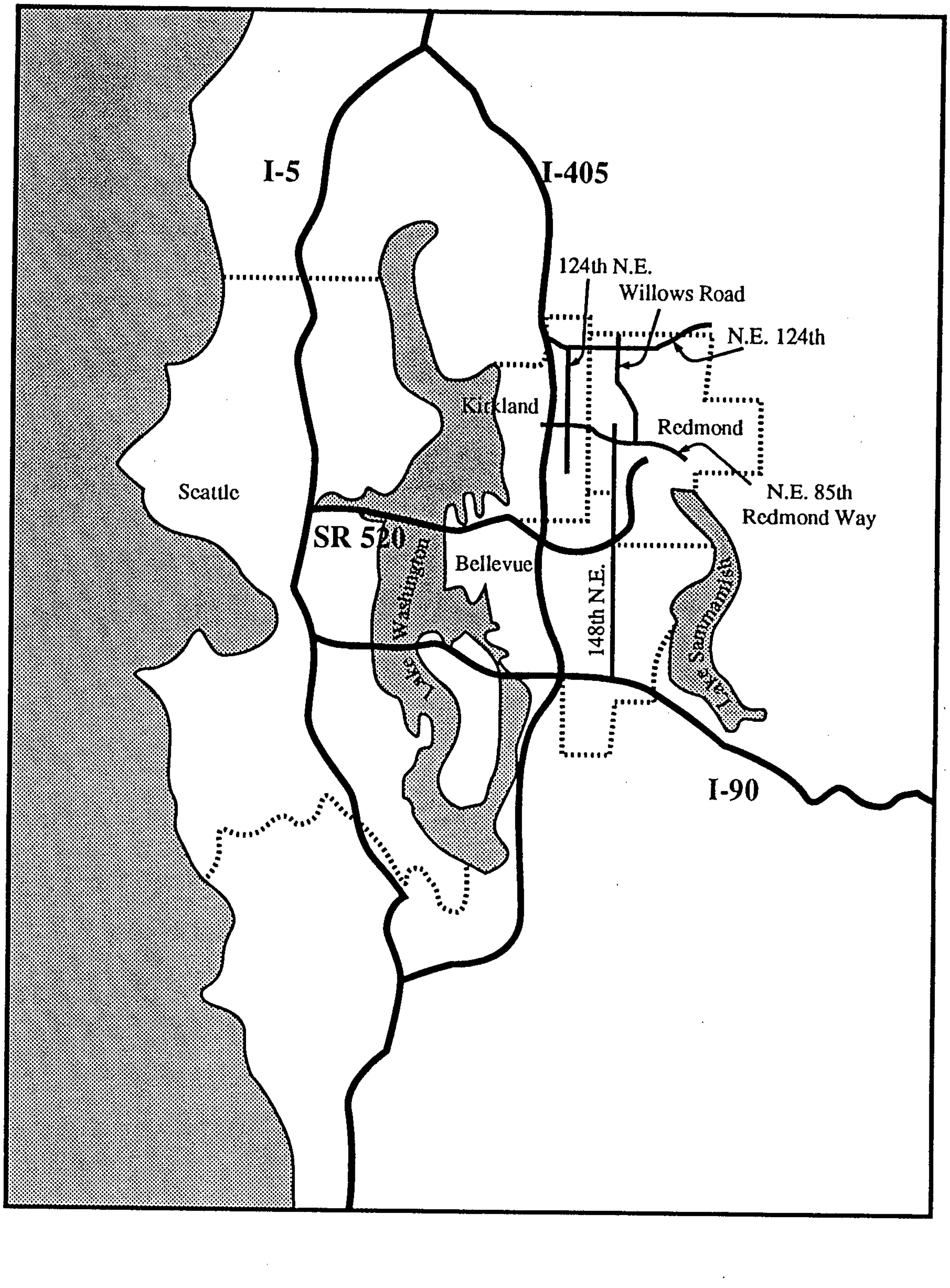

Figure 5. Metropolitan Area in Vicinity of N.E. 85th

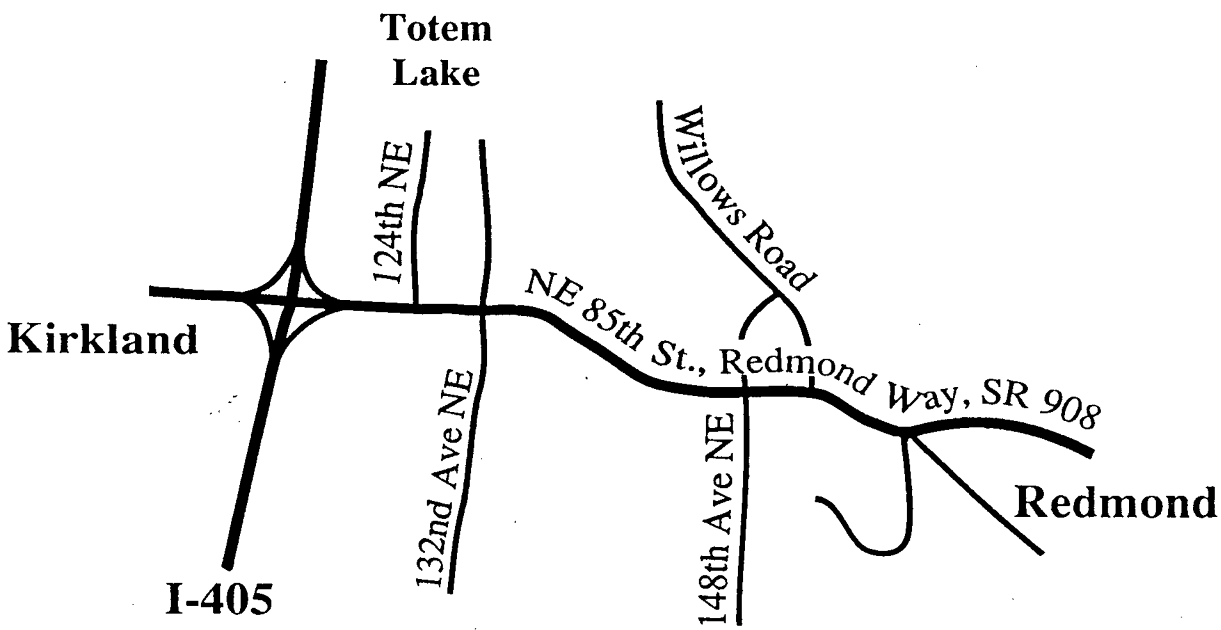

Figure 6. NE 85th Study Area

Another characteristic about the Kirkland/Redmond area that is typical of modern suburbs is the growth in the amount of clean, high-tech jobs that are located there. These jobs, at the eastern end of the study area, create a traffic flow that is actually greater than that of the more traditional "inbound", or western flow. The westbound traffic is headed for employment in Kirkland and Bothell, and to a lesser extent, Seattle and Everett. Residential housing is located at all points on the compass from NE 85th. The city of Kirkland, west of I-405, is a mix of single-family residences, apartments, and condominiums. East of the freeway, housing is almost exclusively single-family in the areas near NE 85th. The Redmond section of the arterial is bordered, for the most part, by large apartment complexes set well back from the roadway. In addition to being near housing, N.E. 85th is the closest east/west arterial to the north end of Lake Samammish, and thus provides one of the few ways to travel west from the large residential development on the hills and plateaus to the east of the lake.

Two thousand copies of the postcard questionnaire were printed up and distributed to morning rush-hour traffic on NE 85th in Kirkland. The survey was handed out during the spread-out peak period from 6:15am to 9:30am on Thursday. One thousand questionnaires were handed out to westbound traffic at the intersection with 124th NE. The other one thousand were handed out to eastbound traffic at 132nd NE.

The balance of the data necessary for analysis was obtained by simple observation, field tests, or other data sources. Bus frequencies were taken from the METRO route schedules. Since bus occupancy was not available from METRO, observations were taken during the survey distribution. Study section travel speeds were acquired by driving the corridor several times using the floating car technique. Traffic counts were obtained from the cities of Kirkland and Redmond.

Traffic Simulation Using TRAF-NETSIM and TRANSYT-7F

For the initial analysis of Pacific Street, the microscopic traffic simulation model TRAF-NETSIM was chosen. This model could represent real traffic characteristics in greater detail than macroscopic traffic simulation models and was also able to simulate complex HOV lane traffic flow. As the project progressed however, several "bugs" were found in TRAF-NETSIM that had to be corrected. Through extensive re-programming of the source code, several of these problems were corrected. However, other problems with the simulation led us to finally abandon use of the animated microscopic software package for a less complicated simulation package. There were several lessons learned, however, from the runs made with the TRAF-NETSIM software and these are well-documented in Volume IV of this report.

The macroscopic arterial simulation package, TRANSYT-7F, was then chosen for use in the HOV simulation runs for both NE Pacific St. and NE 85th St./Redmond Way. In order to use TRANSYT-7F for simulation of HOV traffic, a methodology had to be developed for calculating appropriate platoon dispersion factors. This methodology developed for the project is described in Volume IV.

Several simulation runs were made for possible future scenarios. These included various combinations of expected HOV improvements and possible mode shifts and volume changes.

DISCUSSION

Before-Study of the Planned NE Pacific HOV Facility

This section covers the results of the before study. As previously discussed, the determination to design a before-and-after study and carry out the before study was based on the findings of the state-of-the-art review of the literature. The before-data was collected in the Spring of 1990, and a comparable data set is being collected in the Spring of 1992 for evaluation in a follow-up study jointly sponsored by METRO transit and Transportation Northwest (TransNow).

The final set of NE Pacific St. data for the before study consisted of 298 observations. The data set for the Montlake Blvd. NE arterial consisted of 223 observations. Table 1 summarizes the data obtained on the chosen evaluation variables for the before study field observations. The regression analyses were performed using these data to identify existing relationships for future comparison with the after study. These regression analyses are detailed in Davis, Chapter 6 (8).

The state-of-the-art review (Volume II) found that safety concerns are often expressed for arterial HOV facilities. In order that comparisons could be made later, it was important to obtain information on existing accident rates. The Seattle Engineering Department provided a listing of accidents along NE Pacific St. for the previous 75 month period from January 1, 1984 to March 24, 1990. This listing provided the date of each accident, the type (auto, pedestrian, bike, other), whether or not there were injuries, weather conditions, light conditions, and road surface conditions. The list was organized into groups by location for seven different locations along NE Pacific St. These locations are described in Table 1 below.

Table 1. Locations, Aggregations For Accident Data

Location	Description
1	15th Ave NE and NE Pacific St. intersection
2	NE Pacific St: 15th Ave NE to 17th Ave NE crosswalk
3	NE Pacific St. at the 17th Ave NE crosswalk
4	NE Pacific St: 17th Ave NE crosswalk to NE Pacific Pl.
5	NE Pacific Pl. and NE Pacific St. intersection
6	NE Pacific St: NE Pacific Pl. to Montlake Blvd. NE
7	Montlake Blvd. NE and NE Pacific St. intersection

Table 2 gives the summary of accident data by location along NE Pacific St. Overall the data show an average of 1.35 accidents per month for NE Pacific St. between 15th Ave NE and Montlake Blvd NE. Accident data collected after the implementation of the HOV facility will not be strictly comparable because presumably other factors such as general growth will have occurred during the six-year before period represented by these statistics. The baseline can only provide an indication of the typical accident rates. Accidents are infrequent events with high variance. Hence, before and after comparisons will be difficult.

Out of 1700 cards distributed on Montlake and Pacific, 503 or 30% were returned with responses to questions 8 and 9. On question 8, the respondent had to evaluate driving alone compared to a carpool [see Figure (4)] Question 9 was identical except that 'bus' was substituted for 'carpool'. Responses were coded 1-5. "Always" was coded as 1, "Usually" as 2, and so on. The responses were averaged to provide an indication of where the attitude of the group as a whole could be represented on the scale. Table 3 summarizes the attitudes towards buses and carpools as reflected by the survey questionnaire. The results for these attitude questions were interesting yet reasonable. The respondents in vehicles with 1 or 2 occupants, which will be designated as low occupant vehicles (LOVs) for convenience, rated driving alone higher than the carpoolers or bus riders. The sample for carpoolers was small, but carpoolers on NE Pacific St. ranked driving alone much lower (3.40). In other words, carpoolers demonstrated support of carpools by rating driving alone as only sometimes or seldom better. Note, however, that the attitude toward carpool and buses was not as high among the Montlake carpoolers who were more supportive of driving alone.

The attitude towards driving alone was lowest for the sample of bus riders who, as a group, would seldom rate driving alone as better than the bus (4.23). The attitude toward driving alone was higher for the LOVs on Montlake than on Pacific and the standard deviation was lower. Thus they were consistently supportive of driving alone. The highest group average for driving alone was from the Montlake group in comparison with riding the bus. This makes sense because there is less bus service available on Montlake than on NE Pacific St..

Overall, the results from the survey were reasonable. They suggest that the travelers on NE Pacific may be less supportive of driving alone than the travelers on Montlake. The results are encouraging because they suggest the possibility for mode shift. The results provided a baseline for comparison if the same survey is repeated after the HOV lane is implemented.

Table 2. Summary of Accident Data By Location

Location Number	# of Accidents	% Involving Bicycles	% Involving Pedestrians	% Resulting In Injuries	% Accident Days Unclear Weather	% Ocurring at Dusk or Night	% Ocurring On Wet Road	Average # Monthly Accidents	% of Pacific St. Accidents
1	19	16	0	47	11	42	26	.25	.185
2	10	0	10	40	20	20	30	.13	.096
3	2	0	100	100	50	0	100	.03	.022
4	7	0	14	43	57	57	57	.09	.067
5	14	29	36	71	50	43	57	.19	.141
6	34	0	0	21	15	1	29	.45	.333
7	15	33	13	53	7	13	13	.20	.148
Total	101	12	11	50	22	25	34	1.35	

Table 3. Summary Attitudes Towards Buses and Carpools

(Mode) Loc.	# OBS	Q8 MEAN	Q8 SD	Q9 MEAN	Q9 SD
(LOV) Pacif	226	2.11	1.32	1.80	1.03
(LOV) Mont	250	1.79	0.99	1.68	0.89
(HOV) Pacif	10	3.40	1.51	2.30	1.57
(HOV) Mont	16	2.56	1.59	1.81	0.75
(BUS) Pacif	48	4.10	1.42	4.23	1.13

LOV = Persons in vehicles with 1 or 2 occupants
HOV = Persons in vehicles with 3 or more persons (Carpools)
BUS = Persons in buses

The sample of surveys for NE Pacific St. provided some general information about the numbers of trips starting or ending in the University District, the average length of trips, and the persons traveling on NE Pacific St. during the peak. These summaries of general travel and travel profiles are given in Tables 4 and 5 below.

Table 4. Age, Sex, and Income Profile (NE Pacific St. Travelers)

Mode	# OBS	Age	Male	Average Income
LOV	149	52	48%	$44,000
Carpool	11	53	27%	$53,000
Bus	46	35	28%	$31,000

Table 5. Trip Purpose, Origin, Destination, Length (NE Pacific St.)

Mode	# OBS	Work	School	Origin	Destination UW	Distance UW (miles)
LOV	149	58%	7%	57%	17%	11.5
Carpool	11	45%	9%	45%	18%	9.9
Bus	46	65%	22%			9.9

The average age of persons in carpools and LOVs was high. This may be due, in part, to some sample bias, since younger persons apparently did not return the surveys as consistently as older persons. Also, 58% of the LOV respondents and 45% of the carpool respondents marked the purpose of their trip to be "work", corresponding to 7% and 9% respectively for "school" related trips.

The LOV users were evenly split between men and women, while the carpoolers and bus users were predominantly female. The household incomes were fairly high for persons using LOVs and carpools, and much lower for persons using buses.

The trips on NE Pacific St. were mostly work related. School trips comprised a small portion of the whole, though the portion of students using the bus (22%) was double the portion for LOVs and carpools (7% and 9%).

Most LOV and carpool trips had either the origin or the destination in the University District. For NE Pacific St., 57% of LOV trips and 45% of carpool trips had started in the University District, while 17% of the LOV trips and 18% of the carpool trips had destinations in the University District. Altogether, the majority of the LOV trips and the majority of the carpool trips had either an origin or destination in the University District. Note that because the bus sample was collected at a bus stop in the University District, all passengers were either originating or destined for the University District (data on transfers were not taken for this study). The lengths of trips averaged about 10 miles. Trips for LOVs were slightly higher (11.5 miles) than carpool or bus trips (both 9.9 miles).

Several generalizations can be made about trips on NE Pacific St. eastbound during the peak period, keeping in mind the sample bias. First of all, the trips were largely work related. Travelers on NE Pacific St. during this period were older and more affluent than might be expected. Most of the trips started in the University District. The results suggest that only a small portion of the travelers were using NE Pacific St. as a corridor for regional type travel starting in neighborhoods other than the University District. Approximately 31% of the persons were traveling to the east side across SR-520. Another 36% were going to nearby neighborhoods in Seattle (Montlake and Capital Hill). Of the remaining trips, 7% were going to the Rainier Valley area, 7% were going to destinations in South Seattle or Pierce County, and 2 to 3% had destinations downtown, Queen Anne, West Seattle or Mercer Island. The rest of the trips were divided among destinations scattered all over the region.

Travel Survey For NE 85th St.

The balance in commute flows along NE 85th is reflected in traffic counts taken by the cities of Kirkland and Redmond. Table 6 shows these AM peak hour flows. The Kirkland numbers, are from the intersection of 124th NE and the Redmond numbers were taken at 140th NE.

Table 6. A.M. Peak Hour Flows (VPH)

	124th N.E. week of 9/24/90	140th N.E. 6/19/90
EB	1278	1355
WB	1198	1274

The travel survey contained questions asking for the address of, or nearest intersection to, the origin and destination of each trip. These locations were aggregated into zones to create origin-destination matrices for the trips along NE 85th. The zone boundaries used were those of the PSCOG. Volume III of this report includes a listing of the PSCOG zones included in each study zone and a description of each.

The largest movements were for trips with neither origin nor destination in the Seattle CBD. The westbound origins show that 43% of the trips begin in West Redmond, 25% begin on the Sammamish Plateau, and 14% in NE Kirkland(Rose Hill). The westbound destinations show that 39% of all the trips are to NE or downtown Kirkland. This, opposed to only 9% going to all parts of the city of Seattle, stressed the fact that travel on the arterial is suburb-to-suburb. Thus, for westbound traffic, NE 85th serves the zones immediately to the north and east of Lake Sammamish and provides access to Kirkland and all parts of the metropolitan area via I-405.

Eastbound, 84% of the trips are destined for Redmond. They are broken up as follows: 44% to the Overlake area with Microsoft, Nintendo, Safeco, and Group Health; 20% to downtown Redmond; 10% to the Bear Creek area; and 9% to the business parks along Willows Road. The origins are predominantly from NE and downtown Kirkland (32%) and from the Kirkland-Bothell-Woodinville area (26%). Longer trips that were significant included 6% originating from the Lynnwood area. Again, the predominance of travel for eastbound traffic is from zones in the immediate Kirkland-Redmond area, meaning that the commuters are people who are probably on this road for many other reasons during the week than just going to work.

Table 7 shows the vehicle occupancy results obtained from the survey. It is interesting to note the high percentage of carpool vehicles currently in the traffic stream on a route with relatively short trips and currently without any HOV priority lanes in either direction. Eastbound the carpool volume is 11.1% of all trips, and westbound it is 14.1%! Obviously, there are other factors already supplying substantial incentive to rideshare.

Table 7. Vehicle Occupancy

		Number	Percentage
EB	1	311	89.88
	2	30	9.65
	3+	5	1.45
WB	1	244	85.92
	2	30	10.56
	3+	10	3.52

The survey also obtained the average perceived travel time for trips during the AM commute. Table 8 shows these travel times by occupancy. The results were surprisingly similar, with the eastbound average at 28 minutes, 51 seconds and the westbound at 29 minutes, 31 seconds, a difference of only 2.31%. As would be expected, people who are currently carpooling are those with the longest trips, where the incentives to carpool are greatest.

Table 8. Travel Time by Occupancy (minutes:seconds)

	Eastbound	Westbound
1 person	28:17	29:36
1-2 persons	28:49	29:21
2+	34:37	30:43
3+	35:00	41:13

Table 9 shows the breakdown of trips by trip purpose obtained from the survey. Linked trips that were recorded as having additional purposes besides work were counted as only work trips. The notable fact about the numbers in Table 9 is the higher number of social-recreational and other trips for the westbound traffic. This is probably due to the nearness of the westbound origin zones. People would be using NE 85th to access the freeway for these other trips.

Table 9. Trip Purpose

		Number	Percentage
EB	Work	327	94.51
	Shopping	2	0.58
	School	7	2.02
	Soc-Rec	8	2.31
	Other	2	0.58
WB	Work	256	90.14
	Shopping	2	0.70
	School	6	2.11
	Soc-Rec	11	3.87
	Other	9	3.17

Table 10 shows the survey response to the question asking how likely the person would be to carpool to work if HOV lanes were installed on NE 85th from I-405 to 148th NE. The numbers are virtually identical, with the biggest difference in any category being only 1.11%. It is interesting that the percentage of eastbound motorists in the two groups that were most likely to carpool to work (10.65%) is very close to the existing carpool volume for all trip purposes (11.46%). For westbound traffic, on the other hand, there are fewer people who are most likely to carpool to work (9.00%), than are currently doing so for all trip purposes (17.30%). This reflects the high percentage of non-work carpools currently in the westbound traffic.

Table 10. Likelihood of Carpooling
(Number and Percentage)

	Eastbound		Westbound	
Definitely Would Carpool	14	4.14	10	3.60
Very Likely to Carpool	22	6.51	15	5.40
Somewhat Likely to Carpool	77	22.78	65	23.38
Definitely Would Not Carpool	225	66.57	188	67.63

Table 11 shows the survey response to the question dealing with some of the problems usually associated with belonging to a carpool. As it turned out, one of the most common reasons was left off the question list, but some 90 people took the time to write it in. That was the need of their personal car either at work for business, or during the day, or on the commute for personal use. Adding in this popular category, the results are shown in terms of number of responses and percentage of observations. Note that the percentages do not add up to 100% as this was one question where multiple answers were allowed. There does not appear to be any significant differences due to direction of travel in this response. The length of the questionnaire did not allow finding out any more about the most troublesome problem, hours of the day worked. It is not clear whether this is long hours, unpredictable overtime, part-time, or an unusual shift. Most of the reasons are probably very valid deterrents to carpooling. Having to go in early or stay late at work just to catch a ride would be very unusual for American suburbanites.

Table 11. Problems of Carpooling (Number and Percentage)

	Eastbound		Westbound	
Home Location	143	40.97	109	37.72
Work Location	72	20.63	83	28.72
Hours Worked	214	61.32	182	62.98
Days Worked	28	8.02	33	11.42
Need Car	52	14.90	46	15.92

The one problem that probably appears bigger than it really is, is the first one, home location. The great majority of commuters along NE 85th come from well established, relatively densely developed, suburban communities. And, especially for westbound traffic, the number of areas is fairly small. The fact that 40% of the motorists believe that no one lives near them that also wants to carpool is most likely a result of ignorance, having never really investigated the situation. It would be very interesting to see the results of a carpool matching service in this area.

Finally, the comment section at the bottom of the travel questionnaire was used, in one form or another, by 334 of the 638 respondents, or 52%. Comments that were more or less transportation related were grouped into 19 topics. These, and their breakdown by direction, are shown in Table 12. Not all comments, by far, were for more construction. In fact, a few did not want any improvements simply because they did not want to drive through the months and years of construction, which seems so prevalent in the Seattle area these days.

Again, multiple comments were recorded for individual questionnaires. The percentage of transportation related comments from eastbound traffic was virtually the same as that from westbound (39.83% vs. 39.45%). Totalling the number of negative comments, those either asking for something else to be built first, or just opposed to HOV lanes here or anywhere else, gives 46 responses or 13.18% for eastbound and 35 responses or 12.11% for westbound. Thus, the similarities in the two directions show up in this question as well.

The differences that do exist for the two directions are interesting. Eastbounders want improvements to I-405 much more, which is reasonable since more of them travel on it to and from distant zones. Conversely, they are also more opposed to HOV lanes in general, and are much more interested in having more bike lanes.

The eastbound population, therefore, can be considered somewhat more heterogeneous than the westbound. This response can be explained from the fact that their origins are more dispersed.

Other than the previously mentioned comments about needing a car at work, the next most popular theme was for better transit. People said if they could ride a bus, they would, but the routes either did not go where they wanted, when they wanted, or they took so long it was unreasonable. This, as was mentioned in the introduction, is the plight of the suburbanite. Their land use has effectively prevented transit from being able to serve all the spreadout residences and employment centers.

Table 12. Survey Comments

	EB	WB
Fix the SR 520/Avondale Road intersection first	1	6
Taking kids to daycare creates carpool problems	6	7
Build HOV lanes on I-405 first	10	3
Build ramp meters on I-405 first	2	1
Build HOV lane somewhere else first	0	1
HOV lane on N.E. 85th good idea	2	3
HOV lane on N.E. 85th bad idea	6	9
Need car for personal use during the day	6	4
Need car for personal use during commute	9	4
Need car for work	37	38
Suggest regional rail project be built first	6	9
Build more roads	7	5
Improve the transit service	17	11
Coordinate the signals on N.E. 85th	2	5
Prefer 2+ lane occupancy if HOV lane is installed	6	2
Prefer 3+ lane occupancy if HOV lane is installed	1	0
No more construction	2	2
Build more bike lanes	10	1
Against HOV lanes in general	9	3

Simulation Results

As mentioned in the Procedures section, both TRAFNET-SIM and TRANSYT-7F were used in simulating potential impacts of HOV improvements on NE Pacific St. in Seattle and NE 85th St. in Kirkland/Redmond area. After several iterations of program refinement with the TRAFNET-SIM software, it was decided to use the macroscopic TRANSYT-7F results as the more reliable forecasts. A complete description of the simulations and their significance is given in Volume IV of this report. Only the final TRANSYT-7F simulation results will be discussed in this section.

NE Pacific St. Simulation. Table 13 gives the simulation results for the expected impacts of HOV improvements to NE Pacific St. Alternative 1 represents the existing system with no HOV improvement. Alternative 2 includes adding one general lane in front of the UW hospital. Alternative 3 (the planned HOV improvement) includes adding one HOV lane in front of the UW hospital. Alternative 4 includes extension of the general lane back to 15 Ave NE and alternative 5 includes extension of an HOV lane back to 15th Ave NE. As the table shows, the improvements on NE Pacific St. have little effect on traffic on Montlake Blvd.. This is to be expected, if there is no change in signal timing due to the HOV improvement. (Note that the planned advanced green time for buses on NE Pacific St. was not modeled here due to time limitation.)

Table 13. Seattle NE Pacific St.
Simulation Travel Time (sec) Outputs

Simulation Alt. Name	Pacific St			Montlake Boulevard		
	Auto	Carpool	Bus	Auto	Carpool	Bus
01.Existing Design	175.8	175.8	266.4	181.2	181.2	258.0
02.Add one gen. lane UW Hosp.	157.1	157.1	249.6	181.7	181.7	258.0
03.Add one HOV lane UW Hosp.	167.7	151.9	244.8	181.4	181.4	258.0
04.Add one gen. lane 15th Ave	139.3	139.3	240.0	181.7	181.7	258.0
05.Add one HOV lane 15th Ave	162.2	126.3	235.2	181.4	181.4	258.0

As expected, adding one general lane to NE Pacific St. improved conditions for general traffic with a savings of 18.7 seconds for auto and carpool and a savings of 16.8 seconds for bus. The planned HOV lane improvement in front of the UW Hospital improved carpool travel time by 23.9 seconds and bus travel time by 21.6 seconds without hurting general traffic (auto actually improved by 8.1 seconds). Adding one general lane all the way to 15 Ave NE improved traffic flow for all modes with a decrease in time for auto and carpool of 36.5 seconds and bus of 26.4 seconds. Adding an HOV lane back to 15th Ave NE improved carpool and bus further (savings of 49.5 and 31.2 seconds respectively) at the expense of general traffic. However, general traffic still had a savings of 13.6 seconds for this alternative as compared to the existing design.

Although the travel time savings for this very short section of arterial may not seem large, they must be taken in context with the entire surrounding system of HOV improvements.

NE 85th St. Simulation. Table 14 shows the simulation results for a proposed HOV lane addition in each direction on NE 85th St. and its comparison with the existing geometric design and with a corresponding general lane or HOV lane addition in each direction. For the eastbound traffic, travel time savings for general traffic are 112.7 seconds and 65.5 seconds for the general lane addition and for the HOV lane addition respectively. Corresponding travel time savings for carpools were 112.7 seconds for the general lane addition and 130.6 seconds for the HOV lane addition. A comparison of carpools using the HOV lane vs. general traffic showed a travel time difference of 65.1 seconds meaning that carpoolers save slightly more than one minute over general traffic for this short section of arterial. In the westbound direction, the savings were less dramatic but still possibly significant when viewed as a contributing piece of a larger arterial network with other HOV improvements.

Table 14. NE 85th Street Simulation Travel Time (sec) Outputs

Eastbound NE 85th Street

	120th to 132nd		132nd to Willows		Total	
	Auto	Carpool	Auto	Carpool	Auto	Carpool
Alt. 01 Existing Geometric Design	122.6	122.6	344.0	344.0	466.6	466.6
Alt. 02 Add one Gen. Lane (140th-Wil.)	122.6	122.6	231.3	231.3	353.9	353.9
Alt. 03 Add one HOV Lane (140th-Wil.)	122.6	122.6	278.5	213.5	401.1	336.0

Westbound NE 85th Street

	Will.to 132nd		132nd to 120th		Total	
	Auto	Carpool	Auto	Carpool	Auto	Carpool
Alt. 01 Existing Geometric Design	195.0	195.0	203.9	203.9	398.9	398.9
Alt. 02 Add one Gen. Lane (132nd-120th)	195.0	195.0	145.9	145.9	340.9	340.9
Alt. 03 Add one HOV Lane (132nd-120th)	195.0	195.0	171.6	134.3	366.6	329.3

Evaluation Criteria. The simulation results for the suggested HOV lane additions on NE Pacific St. and NE 85th St. give some positive indications of success of both of these arterial improvements. One of the most popular performance values used in freeway HOV lane evaluation is the one minute per mile of HOV lane rule [FUHS (9),Hank and Lomax (10)]. This rule states that the travel time savings for HOV lane traffic must be one minute per mile of HOV lane in order for a successful mode shift to occur. Volume IV of this report develops a parallel justification for applying this same rule to arterial HOV lane evaluation. This being the case, addition of the 1000 ft. queue jumper in front of the University of Washington Hospital on NE Pacific St. produces a difference of travel time between carpools and general traffic of 1.39 minutes per HOV lane-mile. According to this criterion, then, it can be argued that the HOV incentive here is sufficient to attract new carpoolers from the general traffic. Although bus time does improve from the existing system, it is still not competitive with general traffic, so a mode shift here is less likely. The results for the eastbound 4200 ft. HOV lane on NE 85th St. are similar. The savings in travel time for those using the HOV lane are 1.36 minutes per HOV lane-mile. (Since bus traffic is virtually nonexistent on this route, it is not a factor in the evaluation.) On westbound NE 85th St, however, the travel time saving for carpoolers is only .78 minutes per HOV lane-mile. Therefore, if this were the only criterion for success, the westbound HOV lane addition would not be considered viable.

Another rule of thumb seen in the literature is that people are likely to switch to the HOV mode if their travel time savings are five or more minutes per trip [Wesemann (11)]. Since the arterial improvements in question make up only a portion of the travelers' trips as documented by our origin and destination studies, we must look at these HOV improvements as they are couched within the larger network. In each of the two case studies described here, the arterial in question connects directly with a freeway that includes an HOV lane bypass on the freeway ramp. The HOV lane for travelers on NE Pacific St. leads into the HOV ramp bypass on SR-520; the eastbound NE 85th facility leads into the I-405 HOV ramp bypass and the continuing I-405 HOV lanes. Thus, if the travel time savings for HOV improvements are accumulated with other HOV supplemental facilities, these improvements look even better. Consequently, the simulations indicate that these HOV lane projects will contribute to improving the existing traffic congestion by encouraging people to shift mode from SOV's to HOV's.

APPLICATION AND IMPLEMENTATION

The results of the current study will be widely disseminated throughout the region and used by the Washington State Department of Transportation, the Eastside Transportation Program, and METRO Transit in assessing plans for other HOV improvements in the region's arterial network. There are extensive plans for HOV improvements on our freeway and arterial system in both King and Snohomish Counties over the next decade. It is hoped that the two case studies analyzed in this report will provide good preliminary information for other such projects that are now in the works and give some insight into how these will contribute to the overall system of both freeway and arterial network improvements.

The extensive before-data set developed for the NE Pacific St. study will be used in a follow up study sponsored jointly by Metro Transit and Transportation Northwest (TransNow). This before-data set collected in the Spring of 1990 will be compared to a similar after-data set collected in the Spring of 1992. This will lead to one of the few documented before-and-after studies for HOV arterial improvements in the nation and should be useful for future planning as well as informational for the NE Pacific St. case.

CONCLUSIONS AND RECOMMENDATIONS

The extensive before-data collection for the NE Pacific St. HOV study showed that out of 1,869 vehicles sampled on NE Pacific St. during the before study, 129 (7%) had three or more occupants. For Montlake, 48 out of 963 vehicles (5%) were 3+ carpools. In addition to this existing pool of 3+ vehicles, the traveller's survey found a population with potential for mode shift. Most of the travellers on NE Pacific eastbound during the peak were found to be older, work-related commuters coming from the University District. Their attitudes toward transit and carpooling were favorable as compared to travellers on nearby Montlake Blvd.. The simulation runs for NE Pacific St. tended to reinforce the specific design decisions of the HOV facility plan. The suggested HOV improvement passed the rule of thumb criterion of a difference in travel time between the general traffic and the HOV lane of over one minute per HOV lane mile. It is suggested in the literature, that this difference is enough to encourage mode shift from SOVs to carpools. These facts, coupled with the surrounding network of HOV facilities including the 520 HOV bypass accessed by a significant portion of NE Pacific St. traffic, suggests that the planned 3+ queue jumper lane will, in fact, be considered a success. Because of the extensive before-data collection developed for this case study, this conclusion can and will be tested in an ongoing follow-up study sponsored by TransNow and Metro.

Similar findings were obtained for the suburban arterial NE 85th St.. The traveller's survey showed that existing traffic already had over 11% of 2+ carpoolers in the eastbound direction and over 14% of such carpoolers westbound. The simulation results indicated that the eastbound traffic also passed the 1 minute travel time saving per HOV lane mile criterion. With increased traffic volumes, it is expected that the westbound traffic can also satisfy this criterion in the future. These preliminary results plus the extensive planned HOV improvements on the eastside (including the HOV bypass on I-405) suggest that the addition of a 2+ HOV lane in the eastbound and westbound directions on NE 85th St. would be cost-effective. This should be coupled with an aggressive ride matching and commuter information program since the traveller's survey indicated that a significant number of those travellers who are not currently carpooling were unaware of other travellers with the same origins and destinations.

Thus the preliminary findings of these two case studies suggest favorable outcomes for the planned HOV improvements. These, however, should be viewed cautiously since it must be recognized that there are so many factors influencing the utilization of an HOV application that one cannot make a judgement solely on the basis of the data presented in this report. It must also be remembered in that each case the arterial in question is just a small link in a very extensive system of region-wide priority lanes. One cannot justify the system by evaluating the pieces one by one. Each segment of the network provides much of its value simply by being a part of the whole. With these factors in mind, the report on the two case studies presented here is optimistic.

REFERENCES

1. Institute of Transportation Engineers, "Guidelines for High Occupancy Vehicle (HOV) Lanes: A Recommended Practice". ITE Technical Council Committee 6A-16, 1985.

2. Dennis L Christiansen, "High Occupancy Vehicle System Development in the United States" Texas Transportation Institute. 1990.

3. Thomas M. Batz, "High occupancy Vehicle Treatments, Impacts, and Parameters: A Synthesis". Prepared for New Jersey Department of Transportation. August 1986.

4. National High Occupancy Vehicle (HOV) Facilities Conference. Conference Proceedings: Fifth National High Occupancy Vehicle (HOV) Facilities Conference: HOV Facilities-Coming of Age: April 28-May 1, 1991, Seattle, Washington.

5. TRANSPO Group, Incorporated, "Highway 99 High Occupancy Vehicle Study, Technical Report 2", 1991.

6. Larry Senn, Washington State Transportation Center, working paper, 1990.

7. Lester O. Rubstello, term paper, University of Washington, 1991.

8. Gary A. Davis, "A Stochastic, Dynamic Model of Traffic Generation and Its Application to the Maximum Likelihood Estimation of Origin-Destination Parameters". Ph.D Dissertation, University of Washington, 1989.

9. Charles A Fuhs, "High-Occupancy-Vehicle Facilities: A Planning, Design, and Operation Manual". Parsons, Brinckerhoff, Inc. New York. 1990.

10. Hank, R.H., and T.J. Lomax, "A Simplified Approach for Estimating the Cost Effectiveness of High-Occupancy-Vehicle Facilities". Transportation Research Board, 70th Annual Meeting. January 1991.

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